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Avoiding extreme risk before it occurs: A complexity science approach to incubation

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Abstract Crises appearing in many kinds of organizations are found to be mostly caused by management and workers. The acquisition of the Southern Pacific railroad by the Union Pacific in 1996 provides a dramatic case of how tiny initiating events – incubation events – that appeared chaotic, random and unimportant to an arrogant management spiralled into a crisis. This article draws on theories from complexity science to explain how and why such spiralling processes are set off. The various kinds of initiating incubation events are connected to five specific scale-free theories. Knowledge of each scale-free theory, and others, offers managers improved chances of dealing with incubation events sooner. Given that people often 'don't see what they aren't looking for', scale-free theories are a means of lessening cognitive blindness and giving the concept of mindfulness more visual substance. As managers train to be more sensitive to scale-free causes, their chances of avoiding extreme crises are improved.
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Introduction

> People often take too long to recognize that their expectations are being violated and that a problem is growing more severe …. Managing the unexpected often occurs in the earliest stages, when the unexpected may give off only weak signals. (Weick and Sutcliffe, 2001, pp. 2–4)

The problem is that '*weak signals*' very often don't attract the attention of decision makers as being the potential precursors of possible extreme outcomes, whether they are deemed to be good or bad. Mostly they simply aren't seen – or if seen, aren't paid attention to. In contrast to the dominant fear of bias from theory ladenness (Kuhn, 1962; Churchland, 1979; Franklin *et al*, 1989; Guba and Lincoln, 1994), we pick up on the idea that it is quite often the case that '*you don't see what you aren't looking for*', which stems from cognitive blindness (Simons and Chabris, 1999, Simons and Rensink, 2005; Simons *et al*, 2005).

What Weick and Sutcliffe call 'weak signals' in their book *Managing the Unexpected* (2001), Holland (2002) refers to as *tiny initiating events* (TIEs).[1] TIEs often first appear as random, seemingly meaningless events that are easy to overlook or even ignore, and yet they can spiral up into extreme events of disaster proportions. A key crisis management question, then, is that of *how to accentuate the discovery of TIEs and learn how to diminish their effect – manage them away – so that they do not promulgate major crises*.

Weick and Sutcliffe (2001) examine the manner in which '*high-reliability organizations*' such as air traffic control systems, aircraft carriers, nuclear power plants and hospital emergency facilities have learned to pay more attention to Holland's TIEs in the control of risk.[2] Needless to say, TIEs are invariably seen in retrospective analyses of why disasters occur. For example, before 9/11, the FBI was more or less aware of 52 seemingly random and not easily explained events that were ignored, even though the whistleblower, Coleen Rowley, wrote a paper for FBI Director Robert Mueller criticizing the agency for ignoring crucial evidence about *jihadi* training activities and describing failures at one Field Office that had acquired information about a specific Al Qa'ida terrorist, Zacarias Moussaoui, and actually had taken him into custody on 15 August 2001 (Rowley, 2002). Most of the TIEs that spiralled up to cause the total failure of the Union Pacific (UP) railroad after its merger with the Southern Pacific (SP) railroad had already been observed causing slowdowns on the SP *before* the merger – but the UP ignored them until too late. All of the early causes that finally spiralled up into the bank-liquidity-induced worldwide recession were all identifiable early on by some people (Cooper, 2008; Morris, 2008), and even bet against by John Paulson and George Soros – who sold short and thereby made ~US$6.9 billions on the crashing stock markets just between the two of them (Anderson, 2008).

Our focus in this article is on helping managers avoid cognitive blindness in order to see TIEs more clearly and much earlier so that they can shut them down before an extreme event occurs. The crisis management literature defines crises as *incubating* (Turner, 1976) or *smouldering* (Smith and Millar, 2002) inside firms, and states that they begin with small internal events (Lester and King, 2006), and that 80 per cent of these are human related (Mitroff *et al*, 1996). We wish to separate out and focus our attention on *incubation TIEs* that managers might actually recognize and manage *before* they become disasters (for example, see Mitroff, 2000; Barton, 2001; Weick and Sutcliffe, 2001). We emphasize authors who focus on the early TIE-recognition process and who discuss various examples of TIEs – events that *do* actually scale up into extreme outcomes. Given this, we take the view that if managers were to become more familiar with '*scale-free theories*' they would better and sooner be able to see possible scale-free causal developments spiralling into extreme outcomes.

What are *scale-free theories*? These point to TIEs and subsequent developments in firms that could scale up into extreme events. They help managers recognize TIEs earlier rather than when it is too late. We draw from complexity science to explain what scale-free theories are. Andriani and McKelvey (2009) describe 15 theories showing different ways TIEs can scale up into disasters; we discuss five of these in detail, using specific examples from a now classic business case – the disaster occurring after the merger of the UP and SP railroads in the United States – to illustrate how each scale-free theory helps managers see emergent TIEs, and then 'manage' them into irrelevance before they spiral into crises.

We begin with a short review of the basic elements of complexity science that are most relevant to understanding what kinds of incubation TIEs are apt to scale up into extremes. We don't describe the various scale-free theories until later in the merger case description when we can connect each theory to TIEs in the merger situation. Next, we provide a short history of the UP/SP merger, showing how TIEs apply to the situation, ending with reference to Langer's (1989) concept of mindfulness, which was brought into the management literature by Weick *et al* (1999). We then detail the several scale-free theories that we argue help managers look for and see the relevant incubation TIEs, after first describing each scale-free theory and then showing its relevance in explaining various TIE spirals in the merger case.

Background

The veteran crisis management researcher Ian Mitroff defines a major crisis as follows:

> A crisis is an event that affects or has the potential to affect the *whole* of an organization …. It must exact a *major toll* on human lives, property, financial earnings, the reputation, and the general health and well-being of an organization …. More often than not … a major crisis is something that 'cannot be completely contained within the walls of an organization'. (Mitroff, 2000, pp. 34–35)

Coombs (1999) states that 'a crisis is a major, unpredictable event that threatens to harm an organization and its stakeholders. Although crisis events are unpredictable, they are not unexpected'. Mitroff also notes that 'major crises occur not only because of what an organization knows, anticipates, and plans for, but just as much because of what it does not know and does not anticipate' (2000, p. 35). Different hazards pose different but always unexpected risks (Wisner *et al*, 2004). Emergency management aims to avoid risks (Haddow and Bullock, 2004). Risk mitigation aims to prevent hazards from developing into disasters or to reduce their consequences. Smith (2009) defines a crisis as 'an event, or series of events, that exceeds, or comes close to exceeding, an organization's abilities to cope with the task demands of the event'.

Many crises, such as earthquakes, hurricanes, explosions, falling cranes and bridges, floods, and forest fires are not predictable as to specific timing or impact. Although in general we know that there are more fires in dry seasons, avalanche disasters are more likely in the Alps, hurricanes are more apt to hit Florida, and earthquakes more likely in California and Turkey, we can't yet predict specific time and place. These are referred to as '*sudden onset*' *crises*.

In his now classic paper, Turner (1976) focuses on the '*incubation phase*' of a smouldering crisis, that is, the early stage when '*…a chain of discrepant events develop and accumulate unnoticed*' (p. 381; our italics). He finds several similarities across three disasters in mining, rail crossing and a holiday leisure building: rigidities in perception, attention to known problems decoys people away from new incubations, disregard of information from outsiders, and information obscurities. Reason (1990) calls incubation events '*pathogens*' – 'minor causes, misperceptions, misunderstandings and miscommunications' – smouldering in obscurity until a '*trigger event*' leads to escalation (Smith, 2002). Perrow (1984, p. 106) observes that disasters are more likely to occur when the pathogens (TIEs) are '*tightly coupled*', with complex interactions leading to a 'significant degree of incomprehensibility'. Radell (1992) refers to what the Russians called '*storming*' – which occurs when management speeds up production (trying to set a production record at the Wilberg coal mine) or sets up an aggressive schedule (Chernobyl and Three Mile Island).

Turner (1994) blames 'sloppy management' for most of what happens in the incubation period, as does Smith (2006a). ICM: The Institute for Crisis Management (2008a, b) reports that 80 per cent of crises are internal to firms, caused by management and workers. Using Reason's '*Swiss cheese*' model, Smith (2006b) puts all of the pathogens in Turner's incubation phase into his own Swiss cheese management practice model, referring to them as 'pathways of vulnerability'. He notes that the critical elements most likely to foster a progression toward a crisis tipping point are nonlinear dynamics, little forceful evidence calling for change, and increasing interconnections within and among organizations around the world.

Other crises are defined as '*smouldering crises*'. ICM (2008a, b) reports that since the 1990, some 65 per cent of crises reported in the media have been of the smouldering kind. Among many others, Lester and King (2006, p. 3) state that 'smouldering crises begin as small, internal problems that, because of a lack of appropriate managerial attention, become large, public problems'. Smouldering crises are typically 'human-caused crises' stemming from 'defects within the larger organization or system' (Mitroff *et al*, 1996, p. 43). Human-caused crises tend to '*leave a trail of early-warning signals*' (Lester and King, p. 3; our italics). The analyses of what caused the *Challenger* and *Columbia* space-shuttle failures show a number of seemingly trivial early warnings by employees that were ignored until the disasters were triggered by random external events – the *Challenger*'s launch in freezing weather and the large piece of launch debris that damaged the insulation material on the *Columbia*, which showed up on its final re-entry into Earth's atmosphere (Rogers, 1986; CAIB, 2003).

We believe it is important to clearly distinguish between incubation and smouldering – it is easy to see overlap in the definitions. We try to clarify as follows:

- *Incubation*: As we quote Turner above, incubation is defined as 'a chain of discrepant events [that] develop and accumulate unnoticed'. Here it is the incubation TIEs that eventually scale up to cause the disaster. These are, indeed, the causal events that, left unfettered, spiral up to extreme proportions. The 9/11 disaster is a good example of incubation ignored; the early clues were about terrorist TIEs that were ignored long enough that the terrorists could finally organize to produce the disaster. Weick and Sutcliffe (2001) focus on incubation events in the high-reliability organizations they study. Their detailing of the total collapse of the UP after its merger with the SP is a classic example of incubation TIEs that were well known before the merger but were ignored. We will detail this progression later.
- *Smouldering*: These are 'accidents waiting to happen'. Some 'early warning' clues may exist but they are ignored. But the clues, *per se*, don't spiral up to cause a disaster. As was the case with the Challenger disaster, there were clues offered that freezing weather might cause a problem with the seals, but nothing was done and nothing happened until the first early-morning launch in below-freezing temperatures, which caused the seals to shrink and become brittle. In this case, TIEs are in the form of clues that could spiral up to gain management's attention, but bureaucracy suppresses them – they do not spiral up to cause disasters. The problem here is not that early warning clues spiral up to cause an extreme outcome; the disaster happens because

the early clues don't spiral up to get management's attention. Perrow's 'normal accidents' fit here; the clues were not seen or were ignored; the connectivity that occurred at some point was the 'random' triggering event.

While crisis management is only concerned with TIEs scaling up to negative outcomes, we recognize that managers would also like to discover early on and then enable TIEs that could scale up into positive extremes like Microsoft, Walmart or Google. There is risk in bad things happening and in good things *not* happening. Here, however, we focus only on the former. The management problem is *How to transform TIEs into TIE 'levers'* (Holland, 2002) – that is, actions that may be used to *stop* bad TIEs from spiralling into negative extreme events.[3]

We focus on incubation TIEs that are embedded in the human causes of incubation events – *people*; *workers* versus *managers*; *corporate and disciplinary silos and hierarchies* (Turner, 1976, 1994; Mitroff *et al,* 1996); *self-protection* (Mars and Frosdick, 1997; Vaughan, 1997); *human tendencies toward bounded rationality* (Simon, 1957); *groupthink* (Janis, 1972); or, more generally, *cognitive, organizational, and political motivations* (Bazerman and Watkins, 2004) and *networks* (Newman, 2003; Newman *et al*, 2006).

Causes of Scalability: A Complexity Science View

As noted at the outset, academics (Franklin *et al*, 1989; Guba and Lincoln, 1994) and philosophers of science (Kuhn, 1962) mostly worry about researchers so blinded by their theories/beliefs that they often see and report what is not really there – classic cases being the French discovery of 'N waves' (Klotz, 1980; Nye, 1980), 'water memory' (Maddox *et al*, 1988), and Fleischmann and Pons's (1989) reporting of their cold-fusion results. To help managers better see what they really aren't wanting to pay attention to – that is, TIEs – we begin our analysis by defining 'scale-free theories' that serve as ways of sharpening managers' abilities to see TIEs early on. These are theories about how TIEs scale up into extreme positive or negative outcomes.

We begin with scalability, then discuss power-law indicators, and then briefly review some underlying complexity science discoveries. Learning more about these underlying causal processes paves the way toward seeing TIEs sooner and before they scale up into extreme negative outcomes. Scalability is usually indicated by power laws and results from self-organization.

Scalability

Consider a cauliflower. Cut off a 'floret'; then cut a smaller floret from the first; then keep cutting off successively smaller florets in this way. Each subcomponent is smaller than the former, but each exhibits the same shape, structure and genesis. The cauliflower evolved to this state because it is governed by Galileo's 'square-cube law' of surface-to-volume ratio, the biological basis of its survival and adaptation, that is, the surface entities have to keep subdividing to keep surface area at the same ratio as volume increases. Following Haire (1959), Stephan (1983) applies the square-cube law to firm effectiveness. Employees bringing resources (sales, new ideas and technology) in from outside the firm are 'surface' employees. 'Volume' employees are those inside who produce and coordinate. As firms grow, maintaining the square-cube ratio requires adding more surface units or making volume units more efficient. A firm adopting Simon's (1962) architecture of complexity theory – which is also scale-free – would apply his 'near decomposability' rule at all levels – from bottom to top. Jack Welsh achieved this with his 'Be No. 1 or No. 2 in your industry or else …' rule (Tichy and Sherman, 1994, p. 108; somewhat paraphrased), by injecting adaptive tension (McKelvey, 2008) at all levels. These are organizational examples of Mandelbrot's scale-free Fractal *Geometry* (1982).[4]

Fractals often appear as the result of mathematical equations.[5] The cauliflower is different; it is an example of a fractal in nature that results from adaptive Darwinian natural selection processes (Iannaccone and Khokha, 1996; West *et al*, 1997). We focus on the latter. Inside bodies, as a result of evolutionary processes, we see fractal structures in DNA base chemicals, genetic circuitry, protein-protein interactions, cell metabolism, bronchial structure and so on (see Andriani and McKelvey (2007) for examples and citations). Many fractal structures in biology are a result of predator/prey dynamics; McKelvey *et al* (2010) cite 19 examples.

Why do fractal structures occur? The mathematical equation is the same at multiple levels of a math-created fractal; the adaptive response of a biological agent depends on the same causes operating at multiple levels of a bio-fractal. Even though the cause is the same at multiple levels, however, the consequence can be nonlinear; that is, nonlinear outcomes resulting when a single event out of myriad very small events gets amplified – for example, by positive feedback – to generate an extreme effect extending across multiple levels. These nonlinear dynamics are explained by *scale-free theories*.

Scale-free theories explain why we see fractal structures and long-tailed, Pareto-distributed phenomena within firms and within organizational populations and ecosystems (West and Deering, 1995; Newman, 2005; Andriani and McKelvey, 2009). Fractal structures emerge because, as in the cauliflower, the same cause applies at multiple levels. While incubation TIEs are required as initiating events, disasters only happen if they scale up in size or consequence – that is, spread throughout a large and essential department or scale up or down to affect other hierarchical levels in a firm. These theories apply when the same causes operate at multiple levels to yield what Gell-Mann (1988, p. 3) labels 'deep simplicity' – a single theory explaining dynamics at multiple levels. Scale-free theories point to a single generative cause to explain the dynamics at each of however many levels are being studied.

Power laws

A Pareto rank/frequency distribution – for example, a distribution of cities and towns ranging from thousands of small villages in one long tail on the Y-axis to the single largest city (London in the United Kingdom; New York in the United States) at the end of the other tail on the X-axis – plotted in terms of double-log scales appears as a power law, which is an inverse sloping straight line (Zipf, 1949; Andriani and McKelvey, 2007). Power laws often take the form of rank/size expressions such as $F \sim N^{-\beta}$, where F is frequency, N is rank (the variable) and β, the exponent, is constant. In most 'exponential' functions, for example $p(y) \sim e^{(ax)}$, the exponent is the variable and e (Euler number) is constant. Power laws are increasingly discovered in social and organizational phenomena. The size of firms follows a power law (Stanley *et al*, 1996; Axtell, 2001). Brock (2000) states that power laws are the fundamental feature of the Santa Fe Institute's approach to complexity science. Gell-Mann (2002) follows this up by stating that complexity phenomena such as scalability and power laws are just as important for scientific study as physicists' traditional axiomatic-based, law-like phenomena, and more importantly for us, are even more important in the study of *living* systems.

Specifically, the extreme outcome at one end of the Pareto rank/frequency distribution is typically an $N=1$ extreme event – a No. 9 quake on the Richter Scale; a worldwide pandemic like the Black Death; the Challenger disaster; or Microsoft and Walmart. At the opposite end the N can run into the millions and more – think of all the Ma and Pa stores.[6] The mean, mode and median do not overlap, as they do in a normal distribution. Methods of good management at one extreme do not apply to the opposite extreme – managing a Ma and Pa store is not the same as managing Walmart. As Axtell (2008) points out, 'the typical firm does not exist'. Managing the median firm is not the same as managing at either extreme. Our interest here, however, is in how events in the 'micro' tail sometimes scale up to the extreme in the opposite tail.

We argue that the power-law discoveries discussed above apply to management and organizations, especially as they are good indicators of fractal structures and scalability in action and, consequently, underlying Pareto distributions (Andriani and McKelvey, 2007, 2008, 2009; Boisot and McKelvey, 2007). There is good reason to believe that power-law effects are also ubiquitous in organizations and have far greater consequences than current management theories presume. As noted above, fractal phenomena in bodies (fish, birds, mammals) (as indicated by power laws) are essential to life and survival in predator/prey ecologies (McKelvey *et al*, 2010). In organizations we see power laws that indicate *entrepreneurship* (Poole *et al*, 2000), *alliance* *networks* (Barabási and Bonabeau, 2003), *bankruptcies* (Fujiwara, 2004), *biotech networks* (Powell *et al*, 2005), *industry growth* (Ishikawa, 2006), *economic change* (Podobnik *et al*, 2006), *product development* (Braha and Bar-Yam, 2007) and *Merger & Acquistion* (*M&A*) *waves* (Park, 2008). Underlying all of these examples are tension, connectivity and TIEs that do, in fact, scale up to form Pareto distributions and power laws. Elsewhere, we list 101 kinds of power-law findings in socio-organizational phenomena (Andriani and McKelvey, 2009).

The foregoing are all based on after-the-fact data analyses, and are all *power-law evidence* of constructive kinds of scalability, fractals and Pareto distributions. For these, Holland's (2002) TIE 'levers' are critically important. TIE *levers* are *tiny initiating/incubation events* with which, by using appropriate scalability levers, managers can 'lever' behaviour in their firms up into dramatic positive Pareto distributions and positive extreme outcomes – like Microsoft, Walmart and Google. Oppositely, in firms like Parmalot, Enron, Northern Rock or Lehman Brothers, the beginnings of 'could-become' power-law distributions that stem from negative TIEs are what managers really want to avoid. This means that managers have to get into the business of checking all sorts of organizational data and distributions to see whether they are negative phenomena beginning to show signs of what could become power laws. If so, managers would want to hammer these power laws and the TIEs that started them back into oblivion.

Tension

Self-organization in complex systems typically appears in the '*region of emergence*' between the '*edge of order*' and the '*edge of chaos*', often termed the first and second critical values of imposed energy or tension (Stauffer, 1987; Kauffman, 1993). We now discuss each in turn.

Edge of order

Prigogine (1955) built on Bénard's (1901) study of emergent structures in fluids. In a teapot, for example, the '*rolling boil*' familiar to chefs describes a phase transition from molecules dissipating heat by vibrating faster in place to molecules circulating around the pot, thereby speeding up heat transfer. Because these emergent structures serve to dissipate energy imposing on a system from outside, he labelled them 'dissipative structures'. This phase transition – which occurs at the so-called '*first critical value*' of imposed energy (what McKelvey (2008) calls 'adaptive tension') – defines '*the edge of order*'. This theory of phase transitions stems from physics (Prigogine, 1955; Haken (1983); Nicolis and Prigogine, 1989; Mainzer, 1994/2007). As systems tip across the edge of order we see phase transitions in which new kinds of order (structure and process) emerge. Because of the bank-liquidity crisis first appearing in 2007 and the following worldwide recession (2008–2010), we now see the economic tension imposed by the liquidity crisis creating a worldwide phase transition in how governments are responding to bail out banks, and in the future work toward a new worldwide bank-regulation process. The free-market thinking of 'Reaganomics', which led to the repeal of the Glass-Steagall Act (created in 1933 to prevent banks from risking depositors' money) in 1999 (Kauffman, 2008), is now being replaced by a more Keynesian-based approach with more government controls over bank risk-taking and use of high leverage (Soros, 2008; Pollin, 2009; Yalamova and McKelvey, forthcoming).

Edge of chaos

Scientists at the Santa Fe Institute focus mostly on living systems and how heterogeneous agents interact and self-organize at the 'edge of chaos' so as to create new kinds of order (Gell-Mann, 1988; Holland, 1988, 1995; Arthur, 1994; and Kauffman, 1993). Between the 'edges' of order and chaos lies a region of emergent complexity, sometimes called the 'melting zone' of maximum adaptive capability (Stauffer, 1987; Kauffman, 1993). Bak (1996) argued that to survive, entities maintain themselves in a state of 'self-organized criticality' (defined in Table 1) near the 'edge of chaos' (Lewin, 1992; Kauffman, 1993).[7] The signifiers of the melting zone are self-organization, emergence and nonlinearity (Holland, 2002). Self-organization occurs when heterogeneous agents in search of improved fitness interconnect under conditions of exogenously or endogenously imposed adaptive tension. New order is an emergent outcome of the self-organizing process.

The fact that extreme events start from TIEs and then spiral up into macrophenomena[8] that are orders of magnitude larger poses a problem: where do they acquire/find the energy to do so? In a linear world, such as the case with neoclassical economics and disciplines inspired by the equilibrium assumption, large-scale deviations from equilibrium (the normal state)[9] can only be generated by large-scale causes that act with the same scale on the effect, that is, the outcome is a linear function of the cause. Instead, in a nonlinear world, the potential of TIEs to cause transformation on a scale completely different from their own has to be explained by a different process. For TIEs to unleash radical change, however, there have to be available – but often invisible and unexploited – sources of energy. 'Incubation', whether physical, biological or human, requires energy inputs; otherwise nothing happens – there is no free lunch.

A well-known example is hurricane formation. The TIEs that combine to produce a hurricane are (1) high temperature; (2) high water temperature; (3) humidity difference between the surface of the ocean and the troposphere; (4) a small instability (TIE) that causes an upward local convective (circular) motion of warm air; (5) the rapid cooling that ensues as the air rises, which liberates further energy (latent heat of condensation); (6) additional air sucked into the TIE-caused initial circular motion that subjects more air to the phase transition of warm-to-cold air; and (7) enough stability in the forgoing conditions for the process to continue long enough for the hurricane to develop. In highly chaotic environments such spirals are impossible.

The 2007 bank-liquidity crisis shows analogous dynamics: (1) 'derivatives' are invented as 'safe' investment formulas, which allow very high leverages; (2) mortgage-backed securities are invented and packaged; (3) approximately $1 trillion Chinese foreign reserves flow into the US bond market; (4) the Federal Reserve 'discount rate' plunges to 2 per cent after the dotcom bust in 2002 and then down to 1 per cent in 2003; (5) people start using 5-year 'teaser' loans to buy houses at low interest, with no requests from banks for credit reports or income statements; (6) the housing bubble starts in several countries; (7) the use of various financial engineering-based loan securitization and investment strategies develops; (8) banks leverage their deposits up to a 30/1, 40/1, 50/1 and even 100/1 margins on loans made across the world; (9) the bubble starts to collapse in the United States in January 2006; (10) the 5-year teaser loans begin to expire in late 2006 and 2007; (11) home-mortgage defaults and foreclosures skyrocket in the United States; (12) US banks exhibit liquidity crises leading to bankruptcies; and (13) the US liquidity crisis spreads worldwide. Any single element listed above may be insignificant in itself and uncorrelated with the final outcome, but it may tap into latent uncertainty that lingers in the markets. Once the wave of selling/buying starts locally, it feeds on itself and spreads like an epidemic (Dornbusch *et al*, 2000; Boyson *et al*, 2008; Gallegati *et al*, 2008; Yalamova and McKelvey, forthcoming). In this case, the availability of funds (the energy gradient or force: in this case Chinese money in the US bond market, the 1 per cent discount rate and very lax mortgage requirements)[10] the pre-conditions energizing the start of the epidemic.

Size of the melting zone

Complex systems exist in a state of dynamical balance in the melting zone (the region of emergence) between the first and second critical values. Below the first, imposing forces push them toward stasis, integration, equilibrium and, ultimately, isolation from the environment and equilibrium. Above the second, quickly changing imposing forces push them toward chaos, frantic change and, ultimately, disintegration. Sandwiched in the zone between order and chaos, systems show emergent complexity. However, the dynamics in the region of emergence when self-organization with respect to crisis management occurs are complicated. We outline some of these dynamics next.

1. Chaos alters the size of the *melting zone* (between the first and second critical values) as follows:

   (a) Chaos imposing on a tension that would normally tip a system over the first critical value disrupts the consistency of the tension, thereby *reducing* its 'tipping' force; chaos makes it harder for a coherent energy force to build up and stay consistent long enough to tip the system over the first critical value.

(b) Chaos imposing at the second critical value *increases* the likelihood of a system tipping across the edge of chaos and into the region of chaos; more chaos makes it easier to tip across the edge of chaos – in effect it lowers the threshold.

(c) Consequently, chaos reduces the size of the melting zone.

2. A reduction in the size of the melting zone has two countervailing effects:

   (a) On the one hand, as the melting zone shrinks, the likelihood that TIEs self-organize so as to scale up into extreme outcomes is reduced – with the result that chaos reduces the likelihood of disasters.
   (b) On the other hand, as the melting zone shrinks, the likelihood of human activities self-organizing to see the negative incubation TIEs sooner, and self-organizing in ways that negate them are both reduced – with the result that the probability of disaster mitigation is reduced.
   (c) By this logic, chaos has no consistent effect in increasing or reducing the probability of extremes.

3. However, a system's ability to tip across the first critical value is a function of both chaos and bureaucracy because both inhibit tipping ability at the edge of order. The findings from many crisis studies are that bureaucratic effects inhibit emergent self-organization of TIEs aimed at negating disasters much more than bureaucratic effects inhibit TIEs that scale up into disasters. Logically, if it were the other way around, incubation-type crises wouldn't happen.

Of course, in principle, the build-up of imposing forces or energy gradients helping or hindering the self-organization of disaster-building TIEs or disaster-preventing TIEs can be monitored. Weick's concept of mindfulness (Weick *et al*, 1999) can be co-opted for this purpose, and can be used as an indicator of the resilience of the system and of the size (thickness) of the melting zone. Mindfulness, then, can be bifurcated into seeing more quickly both kinds of TIEs – that is, those apt to scale up into disasters and those that could be used as levers to negate the former. Constant attention must be given to the level of the imposing energy gradient and the width of the melting zone. The larger the latter, the more robust a firm is against external events and forces impinging on it.

Tension, TIEs and Mindfulness on the UP

Our objective for this section is to illustrate two key features of incubation crises: first, that incubators are usually present in early stages of crises, as

Turner (1976) points out, and second, that the *theory* of TIEs is considerably underdeveloped in the classic discussions of *mindfulness* by Weick *et al* (Weick *et al*, 1999; Weick and Sutcliffe, 2001). We begin with the UP/SP merger – described in detail by Weick and Sutcliffe – which offers a compelling example of how TIEs and their creation of minor crises were ignored by UP management during and after the merger, with a major crisis as the result.

Merger-caused tensions on the UP

The passage of the *Staggers Rail Act* in 1980 led to the almost total deregulation of American railroads. The number of railroads reduced from 40 to 10 and the over-100-year-old *Interstate Commerce Commission*, set up in 1987 to negate rail monopolies, was decommissioned (Avery and Ericson, 2004). In 1995 the *Surface Transportation Board* (referred to as the *Surf Board* by all of the parties injured by the merger (Span, 2004)) approved the UP/SP merger despite the objections of the *Federal Trade Commission*; as well as the *Justice*, *Transportation*, and *Agriculture Departments*; rival railroads, numerous groups of customers, and especially coal shippers who could only use railroads. The UP's acquisition of the SP left the entire American West serviced only by two giant railroads – the UP being the largest in the nation with 30 000 + miles of track (Union Pacific, 2008).

Even before the merger, the risk of future operational problems was readily apparent. The SP had a history of dysfunctional behaviour, bad operation and failures. First, the Marketing Department cut prices so as to overload the railroad to make the Production Department look bad, thereby enhancing Marketing's chief's chances of becoming the CEO. Second, despite increased demand for shipping goods, too many cars were sitting unused because they were in the wrong place at the wrong time, and high locomotive-lease costs and crew overtime ate up the value of the increased business (which was priced too low by Marketing). Third, when customers complained, Marketing responded by cutting prices further, thereby compounding the rail traffic flow problems. Fourth, most of the SP track (which was the primary route between the Los Angeles ship port and Houston) was single-tracked, which meant that trains could not pass each other, which then made it the primary source of congestion, delay and increased customer shipping costs – all of which started the gridlock on the UP after the merger. Fifth, the SP vacillated between reducing double-track and yards to cut down on expenses versus keeping the yards and adding double-track to reduce congestion (Brennan and Norton, 1998; Burke, 1998; Avery and Ericson, 2004; Span, 2004).

Despite the already well-known congestion problems and train-movement failures on the SP before the merger, a requirement of the *Surf Board's* approval was to make over 4000 miles of UP/SP track available to the Burlington Northern Santa Fe (BNSF) railroad (the only competing railroad in the American West), which, needless to say, exacerbated the congestion and traffic-movement failure problems. In addition, the UP cut many SP jobs outright and then closed the SP headquarters, which meant that SP operations employees familiar with SP congestion and with tacit knowledge about quick remedies left the company (they also didn't want to move from trendy San Francisco to the cornfields around Omaha, Nebraska). When remaining SP employees, who knew about the long history of gridlock on the SP, told their new UP bosses about the SP problems and solutions that worked, they were ignored. In their book, Weick and Sutcliffe make special mention of the arrogance of UP managers toward 'expendable' former SP employees.

The UP/SP merger took place in July 1996. UP claimed it would save $627 million. In fact, 'by March 1998 delays in shipments had cost rail customers approximately $1 billion in curtailed production, reduced sales, and higher shipping costs' (Union Pacific, 2008). The UP was allowed to use BNSF tracks to avoid further congestion in Texas. And as we note below, there were accidents and people killed. Ironically, even though the extreme negative outcomes of TIEs on the SP were already evident, UP management's arrogance prevented them from seeing them. Pretty much the same TIEs on the post-merger UP led to an even worse outcome: total gridlock occurring in October 1997 (Frailey, 1998). Needless to say, arrogance and groupthink (Janis, 1972) have to be pretty strong for such obvious knowledge of TIEs not to prevail.

Holland's TIEs that bind on the UP after the merger

To begin, we highlight some of the TIEs on the UP that Weick and Sutcliffe describe (2001, pp. 4–10) in Table 1. Here we try to mention only incidents that are at the level of initial clues – they are seemingly random events that are essentially trivial and occur now and then under normal circumstances; these are *initial* clues – meaning that they are TIEs that show no evidence of scaling effects at this time; there are no obvious reasons to assume scalability at this point in time in terms of any of the scalability theories we describe below. However, they are all clues that things are not going well on the railroad. *Incubation* is close at hand.

Table 1: TIE-level clues

1. Large cuts in personnel	2. Crews on duty longer than the law allowed
3. Fatigued crews	4. Equipment not maintained
5. Dispatchers unfamiliar with assigned territory	6. Shipments lost; can't be traced
7. Speed of trains drops from 19 to 12 mph	8. Crews falling asleep while running trains
9. Four employees killed in yard accidents	10. Collisions kill seven more people
11. Not enough locomotives	12. Trains backing up in Englewood yard

Table 2: Evidence of scalability

1. Shippers upset by delays getting worse and worse	2. Trains stuck on sidings without locomotives
3. 8 October; 550 freights standing still	4. All sidings filled with backed up trains
5. Englewood yard locked up with 6179 cars	6. Stalled trains meant that crews' duty time expired
7. Trains going in opposite directions couldn't pass each other on a single mainline because sidings were filled with backed-up trains	8. As most stalled trains were pointed toward the Englewood yard in Huston, no trains could leave Englewood because of the blocked mainlines
9. 1800 locomotives unavailable because they were stuck in the wrong place	10. Sorting of cars into trains by destination was centralized, thereby exacerbating the delays
11. More engines sent to Englewood to unblock system, but they just added to the blockage	12. Denial of failures repeated at all levels of the hierarchy
13. Top management ignored early warning signs	14. Unexpected events spin out of control
15. 'The system was gridlocked as far away as Chicago' (Weick and Sutcliffe, 2001, p. 6)	

The items in Table 1 are examples of Holland's TIEs – nothing more. In Table 2, we summarize a number of higher-impact events that are set off by these TIEs and are evidence of scalability:

- Cuts in personnel, crew fatigue and on duty too long scales up owing to stalled trains and clogged sidings.
- Poor engine maintenance and tired crews going off the clock scales up as unavailable locomotives and trains stuck on sidings.
- Not enough locomotives and trains stuck on sidings scales up to trains backed up in clogged yards.
- No crews, no locomotives, trains stuck on sidings and yards leads to total system gridlock.

The small events spiralled up into scalable events that eventually led to system-wide gridlock – the ultimate extreme outcome. None of these events could result from a single isolated TIE such as those we mention in Table 1. The latter have to scale up via some causal process such that they have broader impact. We will detail this process in the next section.

Having described what we have reduced to brief descriptions in the foregoing tables, Weick and Sutcliffe then detail some of UP's managerial response. We paraphrase these in Table 3. Needless to say, the list of management failures gives obvious reason to conclude that UP management's style made them truly unmindful. *They rather obviously didn't see what they weren't looking for*; they didn't see all of the TIEs that were present and that they really should have been paying attention to. They could have prevented the disaster if they had been savvier about the fact that their railroad disaster was indeed the result of TIEs that bind.

Table 3: Evidence of management failures

1. Old-line operations guys were running the railroad; CEO started as a brakeman	2. Blamed blizzards, track work, flash floods, derailments, Hurricane Danny, poor maintenance
3. Mentality: UP is the victim not the culprit	4. Ignored early warning signs
5. Failure to articulate important mistakes	6. Didn't organize to detect them
7. Allowed events to spin out of control	8. Had inflated views of its capabilities
9. 'UP … was the poster child of arrogance' (p. 6)	10. 'Crisis times treated just like normal times' (p. 17)
11. 'Preoccupation with success and its denial of failures … repeated at all levels of the hierarchy' (p. 11)	12. 'UP executives neither looked for failures nor believed that they would find many if they did' (p. 11)
13. 'Slowdowns were underreported and allowed to incubate until they were undeniable and … irreversible' (p. 11)	
14. 'People keep mentioning intimidation, a militaristic culture, hollow promises to customers, abandonment of workarounds, production pressure on train crews …' (p. 14)	
15. 'The UP … favored centralization and formalization and treated improvisation as insubordination' (p. 15)	

Weick's approach to managerial responses: Mindfulness to pick up on TIEs

Weick and Sutcliffe's identifications of UP management's failures would appear to provide an accurate description of events, and, in fact, could be broadly applied to almost any kind of organizational failure that is seemingly a result of management failures. By this we suggest that many of the '*mindfulness*' solutions they wish to apply rather narrowly to high-reliability organizations – specifically to negating TIEs early on so as to prevent them from scaling up into extremes – don't seem much differentiated from causes attributed to management failures in general. However, they do mention the following:

- 'Early and ample signs that the UP did not understand…' (p. 8), and failures to detect that allow '… unexpected events to spin out of control'. (p. 9)
- They suggest that managers need to '… treat any lapse as a symptom that something is wrong … that could have severe consequences if separate small errors happen to coincide at one awful moment …'. (p. 10)
- They state that 'resilience is a combination of keeping errors small …'. (p. 14)

In addition, extreme mindfulness can lead to organizations that are in a permanent state of fibrillation and overreact to even minor stimuli -- in other words to 'hypochondriac' organizations. Hypochondriac organizations pay excessive attention to tiny signals and live in a constant state of fear. In this case, mindfulness may lead to fragility rather than resilience. The distinction between inconsequential stimuli (that can be ignored) and TIEs (that have the potential of spiralling up) should be attended to on the basis of evident scale-free theories, as we argue in this article. Management scholars always worry about case writers who are 'theory laden' – they see what their theories tell them to look for (Kuhn, 1962; Franklin *et al*, 1989; Guba and Lincoln, 1994). But the opposite may be true as well: *One doesn't see what one isn't looking for*. For us, scalability dynamics and their causes are what one may not see unless one is better trained to see them. Elsewhere (Andriani and McKelvey, 2009) we describe 15 theories about why scalability dynamics occur. In the next section we describe five of the 15 that most readily explain the various scaling dynamics that Weick and Sutcliffe (2001) describe. If management had been more clued in about how the events we describe in Table 1 scale up into the events we mention in Table 2, the disaster wouldn't have happened.

Using Scalability to See TIEs Sooner: The UP Example

As we have a good example of TIEs scaling up into the total gridlock of the UP railroad across an area approximately 1000 miles north-to-south and 2000 miles east-to-west, we start by describing how several scalability theories apply to organizations in general. We follow each general description with what happened on the UP railroad.

Square-cube-quarter-power law

In biology, many scaling laws take the allometric[11] form $Y \sim M^b$, where Y is some observable and M the mass of the organism. Among these, West *et al* (1997) cite metabolic rate, height of trees, life span, growth rate, heart rate, DNA nucleotide substitution rate, lengths of aortas, size of genomes, mass of cerebral grey matter, density of mitochondria and so on. In general, the exponent b is a multiple of$\pm$¼. The square-cube law applies to the ratio of volume to surface – surface units keep subdividing to stay in constant ratio as volume increases. The '¼ *power law*' stems from fluid flow: volume sets the energy use rate (cube); surface sets the energy absorption rate (square); and the fluid flow rate between surface and volume is reflected in the ¼ power ratio to square and cube. To achieve this, organisms have developed common evolutionary mechanisms based on fractal geometry and fractal flow. We have no direct evidence of this mechanism at work in organizations, but we note that the problem the biologists have solved applies to organizations as well. Firms operate in competitive ecosystems – with M&A activities acting as equivalents to predator/prey fractal dynamics in biological ecosystems – defined by the need to maximize revenues (exchange area between firm and customers) and minimize expenses (energy spent for developing, manufacturing and distributing products). If this constraint on the revenue-energy relationship can be given a meaningful geometric economic form, we may discover similar allometric relationships in organization science.

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UP application

This scalability law was brought into organization theory by Haire (1959). Stephan (1983) translated it into 'surface' and 'volume' employees. Surface employees deal with customers and bring in business and revenues. Volume employees are those who administer and produce products and services. In the UP, then, surface employees connect to customers, and volume employees fix tracks, sort trains in yards, dispatch and run trains, manage things and so on. The ¼ power law, initially applied to blood flows in a body, can also restrict surface or volume growth. Here, it applies to flows of trains and goods over the tracks. From the merger with SP, customers were about doubled; track length was roughly doubled – but train flows along any single track had to stay about the same. Just from knowing the surface-volume law, one can easily see that the railroad is immediately out of balance. Even though 'surface' was roughly doubled, single-track flows remained unchanged. Worse, volume employees were cut when, in fact, the square-cube law would call for increases in either efficiency or numbers at least in some places/jobs. Knowing the surface-volume law, one could easily predict the extreme outcome and then try to manage it away.

Combination theory

Here the only requirement for a power law to emerge is the number of elements in a complex system. This theory begins with Preston's (1981) 'diffonential', which he shows results when two exponential distributions are multiplied – the result is a lognormal. West and Deering (1995) and Newman (2005) both make the case for the simple addition of exponents in the basic power-law equation, $p(y) \sim e^{a,b,c,d \ldots n}$. When this happens, exponentials and/or lognormals in combination create a power law – the more of them that are combined, the longer the tail of the distribution and the more obvious the power law. In this theory, the likely occurrence of interaction is simply *presumed* as a naturally inherent likelihood as systems become more complex. If some number of the elements are individually likely to generate Pareto distributions – as we argue in what follows – combination theory tells us that organizations are inevitably going to emerge as fractal structures unless there are explicit attempts by management to negate these 'natural' dynamics.

UP application

Normal distributions of different variables remain normally distributed if they are combined (even becoming *more* normally distributed, in fact). But if somewhat skewed distributions are combined (even just added together in terms of impact), they become more skewed. If several are combined, the result is a Pareto distribution. Let's suppose that before the merger UP activities were normally distributed – mostly things worked as expected but with some random deviations because of events like the flu or storms. Thus, *normally*, train crews are on time; trains are on time; locomotives are at the right location on time; repair and dispatch crews are on time; locomotives and crews and other railroaders function effectively most of the time, and so on. Then comes the merger. Now each of the foregoing normal distributions becomes skewed. As there are several, and as they interact with combined effects, we see scalability with the result that the entire system becomes gridlocked rather quickly. Because of the cumulative skewing, one could easily predict the extreme outcome and then try to manage against it. Worse, in this case there had already been visible combinations of disruptive events on the SP that clearly shifted 'normal' railroad behaviour toward more skewed distributions.

Least effort

Zipf (1949) argued that '*least effort*' explained his 'Zipf's Law' – a power law of word usage in English, French and Spanish. To put it simply, least effort means, *I won't put effort into using words you are unfamiliar with; you won't put effort into learning words I don't use*. We each, therefore, save energy, become more efficient and eventually use 'least effort'. Least-effort theory is about efficiency. Ferrer i Cancho and Solé (2003) use a computational model to confirm this. Least-effort theory is now shown to apply only under changing circumstances. Dahui *et al* (2005) test whether Zipf's Law applies to Chinese as well as English. Inadvertently, they find something different – the power-law signature applies only during the period before Emperor Qin Shihuang's unification when Chinese characters were changing. They conclude that the law does not apply when the number of characters is stable. The 'change' effect is now confirmed, again inadvertently by Ishikawa (2006), who shows that Pareto's law holds in companies where there is higher rate of growth, but Gibrat's lognormal distribution applies to large firms where growth is slow. Dahui *et al* (2006) show that the distribution of firms in growth markets is a power law but in markets without growth it is Gamma or exponential. Finally, Podobnik *et al* (2006) find empirically – and test further with a computational model – that time-series indices in transition economies (that is, Hungary, Russia, Slovenia and so on) fit Paretian rather than Gaussian distributions. The basic theory, readily applicable to organizations, is that efficient interactive transactions – like people talking to each other or buying-selling – are Pareto-distributed.

UP application

To begin, UP and SP had different tacit, day-to-day and on-the-job languages composed of in-house, local on-the-track and in-the-yards usages; even local, every-day 'management' word usages were somewhat different. When UP took over SP, UP language was supposed to dominate. UP management wanted to take over SP without their UP language and behaviours changing; SP customs, language and behaviours were to disappear. But, of course, they didn't and couldn't. Instead of seeing two organizational tacit and explicit languages transitioning toward a least-effort-based, new, commonly understood language, their languages remained frozen. Frozen languages and markets we now know offer evidence of missing self-organization (Ishikawa, 2006; Podobnik *et al,* 2006). As the two languages changed toward common usage, we should see some terms come to totally dominate the new railroad, other terms appear important but not so dominant, and some words decline to persisting, individual, isolated usage. Knowing this least-effort scalability theory, UP management should reasonably have expected and even tried to enable the development of a new cross-merged railroad language, with word usage appearing as a newly formed power-law distribution (not that we would expect them to know this part).

Preferential attachment

This linear positive-feedback process (Krugman, 1996) underlies biological and social networks, going from groups of individuals to groups of organizations. The most common descriptive phrase is 'the rich get richer' – a basic positive-feedback process – that is, profits from one firm allow a rich person to borrow and buy another profitable firm, and so on. The Internet grows according to preferential attachment (Dorogovtsev and Mendes, 2003). The same happens with cities and airport hubs – larger entities attract even more people or flights (Barabási, 2002). Marketing and sales via the Internet is very much a positive-feedback process (Gladwell, 2000). Any time a system grows by adding nodes to an existing network, its growth will amplify historically generated imbalances among the links. Absent of top-down regulation, older nodes will gain more links and generate a Pareto distribution. As organizations are made up of social networks, preferential attachment plays a crucial role in the formation and evolution of organizations. Other examples are Arthur's (1994) study of increasing returns (firms making profits can invest in things that make even more profits (Microsoft is the best modern example)) and the biotech industry (Powell *et al*, 2005).

UP application

This theory suggests that as the UP and SP social- and work-related networks merged, some individuals would emerge as more 'connectively' important in getting the new system and new ways of doing things up and running. Old dominant nodes could reasonably be expected to be replaced by new 'stars'. Instead, the old-guard railroaders kept themselves and the old separate networks dominant – the old UP network trying for dominance over both railroads; the old SP network in rebellion, passive resistance, and slow-downs rather than joining in a collective reframing of a new combined network.

Managers aware of this theory would expect network dynamics to change dramatically with the merger and would 'manage' toward this end.

Self-organized criticality

When irregular grains of sand fall on a sandpile, the effects of gravity and friction between sand grains cause the sandpile to constantly reshape itself via small-to-large avalanches so as to maintain a specific slope (Bak *et al*, 1987; Bak, 1996). Bak calls this '*self-organized criticality*' (SOC). This effect occurs because the sand grains are irregular and sticky -- not smooth like tiny marbles or *M&M Peanuts*. The distribution of the frequency of the many small avalanches versus a few large ones shows a power law. Arguing that individual decisions are sticky like irregular sand grains, Bak applies SOC to economies. As the tension between supply and demand builds and the actions to reduce it are not of equal size or regularity, economies operate at or near the critical state. Economic fluctuations (business cycles) are SOC (Scheinkman and Woodford, 1994). We see SOC in the price of cotton and financial markets (Mandelbrot and Hudson, 2004), consumer product sales (Moss, 2002, Sornette *et al*, 2004), managerial actions leading to different sized firms (Stanley *et al*, 1996), and in the stock markets of transition economies (Podobnik *et al*, 2006) – all showing power-law signatures.

UP application

UP management at the time of the merger consisted exclusively of old-line railroaders: the CEO started as a brakeman – one of the least skilled people on a railroad. Management was top-down, centralized, thought of itself as victimized, had demeaning attitudes toward workers, and worked to prevent improvization – what we call self-organization. In short, totally top-down control; alas, emergent self-organization was unacceptable. Consequently, there could be no notion or reality of SOC – that is, the workers closest to the operational problems were not allowed (in fact discouraged) to self-organize toward solutions. Consequently, at a most critical time of adaptation, SOC was absent. Bak (1996) and many others (see Brunk (2002) and Frigg (2003) for many more citations) argue that SOC and consequent fractal structures are widespread and essential to biological evolution, change and survival in changing conditions. None of this was allowed at UP. However, management could have used complexity leadership (Hazy *et al*, 2007; McKelvey, 2008, forthcoming; Uhl-Bien and Marion, 2008) to enable SOC dynamics and, thus, more rapid and effective change in response to the post-merger conditions.

Conclusion

We began by distinguishing between *incubation*-based and *smouldering* crises. Turner (1976) uses 'incubation phase' instead of smouldering to describe when '… *a chain of discrepant events develop and accumulate unnoticed*' (p. 381; our italics). Reason (1990) calls incubation events 'pathogens' – 'minor causes, misperceptions, misunderstandings and miscommunications'. Lester and King (2006, p. 3, our italics) state that 'smouldering crises begin as small, internal problems that … *leave a trail of early-warning signals*'. Unfortunately, some definitions of smouldering make it look pretty much like incubation.

We argued that Holland's (2002) TIEs are at the base of incubation-induced crises. Using the 'total-gridlock' crisis resulting from the merger of the UP and SP railroads as a negative risk example, we argued that various external and internal sources of energy gradients (tension) pushed the merged firm over the 'edge of order' into the region of emergence – that is, Kauffman's 'melting zone' (1993). This zone is defined once a system tips over the first critical value (Bénard, 1901; McKelvey, 2001, 2008). But in addition, the tensions in the new UP were so well spread across various levels of the firm that many different degrees of freedom were activated. We showed that although many self-organizing events leading up to the disaster emerged in the melting zone, none of the levers management could have used to dampen them emerged. As a result, a number of negative TIEs were initiated and then scaled up into extreme outcomes affecting large segments of the railroad. Combined, the multiple extreme outcomes here and there across the railroad collectively led to the total gridlock of the UP.

We began with a short pre-merger history of traffic-flow failures on the SP and then describe how TIEs on the UP railroad scaled up to collectively cause total gridlock – drawing from Span (2004), Union Pacific (2008), and Avery and Ericson (2004), along with Weick and Sutcliffe's description of the merger fiasco (2001). We then related TIEs to Weick's '*mindfulness*' (Weick *et al*, 1999). Next, we reviewed key concepts from complexity science, paying particular attention to *first*, scalability and the scale-free causes that serve to escalate TIEs into extreme outcomes; *second*, ideas from econophysics, such as fractals, Pareto and power-law rank/frequency distributions; and *third*, energy gradients as sources of tension that tip systems across the first critical value and into the region of emergent complexity. We payed particular attention to situations in which the region is so narrow that order-creation dynamics at both the edge of order and the edge of chaos are activated in parallel. When this happens, some number of TIEs are simultaneously activated with the result that several TIEs combine to create the equivalent of hurricanes and perfect storms in firms embedded in hi-energy situations and, thus, subject to adaptive tension. Then, drawing from the 15 scale-free theories explaining why some TIEs scale up into having significant effects described by Andriani and McKelvey (2009), we detailed how five of these characterize TIEs on the UP that scaled up to contribute to the total gridlock.

Even though TIEs had already caused extreme negative outcomes on the SP, the culture, arrogance and firing of SP employees in the post-merged UP prevented the latter from seeing the prior-occurring TIEs and results on the SP. Needless to say, there are many other well-known post-disaster studies that have identified the same process. TIEs and employees who see the TIEs early on are simply ignored. The literature on risk management tells this story about incubation crises over and over. Building from the phrase, '*You don't see what you aren't looking for*', our primary argument is that learning about scale-free causes and how they might show up on the UP, or in any other firm, would help managers know sooner and better what kinds of activities might start scaling up into extreme outcomes. In this way we aim to improve managers' 'seeing' ability. Weick is on the right track with his mindfulness concept, but details as to how mindfulness translated into seeing ability remain vague and without much theory or research basis. One can ask, *Mindful about what*? The problem is how to get ahead of post-crisis case analyses and storytelling.

We discussed ways in which five scale-free causes combined after the merger – under the tension of the UP acquiring an already problematic SP – to spiral up to create total gridlock. These causes are widely recognized elsewhere as some of the 15 scale-free causes Andriani and McKelvey (2009) assemble from various sources in the literature. With these, we gave mindfulness theoretical substance. There are indeed various kinds of smouldering TIEs that managers can become more sensitive to in advance. And, finally, managers need to *not* forget that every time increased tension hits, it is what Smith (2002) calls a 'trigger event' – whether the tension is caused by management as in the examples of what the Russians call 'storming' (Radell, 1992), or impinges from the surrounding environment, what are ordinarily meaningless, chaotic, random-appearing incidents that can usually be ignored, all of a sudden have a high probability of combining to trigger extreme negative outcomes.

Notes

1 His actual phrasing is 'small "inexpensive" inputs cause major directed effects in case dynamics' (2002, p. 29).
2 Note that we could just as easily substitute Turner's (1976) 'incubation' for Holland's 'initiating' events in the acronym TIEs; either term is appropriate for us.
3 Elsewhere we focus on how to use TIEs and scale-free theory for better managing toward positive extremes (Andriani and McKelvey, 2009).
4 Fractals are defined as shapes that can be subdivided into parts, each of which is (at least approximately) a reduced-size copy of the whole (Mandelbrot, 1982). The same mathematical equation – or adaptive causal dynamic in biology or in organizations – creates similar causal dynamics at each level of a fractal structure.
5 Rather than take up space to illustrate math-based and nature-based fractals, we suggest clicking on the following URL: http://en.wikipedia.org/wiki/Fractal. It is informative and picturesque.
6 In the United States these are defined as sole-proprietor (or husband and wife-run) stores that do not have paid employees. There are 17 million of them in the United States.

7 In a comprehensive review of self-organized criticality (SOC), Frigg (2003) observes that SOC appears in systems existing in both stable and changing niches. It has also been shown that SOC very well explains punctuated equilibrium in evolving species (Paczuski *et al*, 1995; Boettcher and Paczuski, 1996). Needless to say, punctuated equilibrium, by definition, stems from the coming and going of changing and stable niches.

8 Cities like London and New York spiralled up from the first tiny settlements hundreds of years ago. Honda in the United States spiralled up from their employees' use of 50cc motorbikes in Los Angeles (Pascale, 1984). Walmart began as a one-store operation by Sam Walton. Ford Motor Co. began as the Model T made on one assembly line. Many power-law distributions show many small entities, and also that many of them grow to medium and one extreme outcome.

9 While Eldredge and Gould (1972) were correct in their use of 'punctuated equilibrium' to account for the gaps in the fossil record, most Darwinian selectionist evolution (and all the evidence we have that it is correct) actually takes place in stable ecologies lasting millions of years – like alpine meadows, the Sahara Desert, the Brazilian rainforest, the oceans, and so on. The evolutionary changes we see are evolution toward equilibrium conditions in stable ecologies or contexts (Van de Vijver *et al*, 1998).

10 The Glass-Steagall Act, which was made law in 1933 and prevented normal banks from taking risky investments, was repealed in 1999 (Kauffman, 2008). The Bush Administration, starting in 2002, adopted a policy of relaxing mortgage loan standards so that more minorities could buy houses (Becker *et al*, 2008). Most of the mortgage defaults have been by minority homeowners.

11 Allometry refers to a type of growth in which the parts of an organism grow at a different rate. Therefore, the proportions of the different parts change during growth.

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